FULL TITLE
ASP Conference Series, Vol. **VOLUME**, © **YEAR OF PUBLICATION**
NAMES OF EDITORS

The Algol type eclipsing binary X Tri: BVRI modelling and O-C diagram analysis

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Abstract. CCD photometric observations of the Algol-type eclipsing binary X Tri have been obtained. The light curves are analyzed with the Wilson-Devinney (WD) code and new geometric and photometric elements are derived. A new O-C analysis of the system, based on the most reliable timings of minima found in the literature, is presented and apparent period changes are discussed with respect to possible and multiple Light-Time Effect (LITE) in the system. Moreover, the results for the existence of additional bodies around the eclipsing pair, derived from the period study, are compared with those for extra luminosity, derived from the light curve analysis.

1 Observations and analyses

The system was observed during 5 nights from October 2008 to January 2009 at the Athens University Observatory, using a 40-cm Cassegrain telescope equipped with the CCD camera ST-8XMEI and B, V, R, I Bessell filters.

The light curves (hereafter LCs) were analysed with the $PHOEBE$ 0.29d software (Prša & Zwitter 2005) which uses the 2003 version of the WD code (Wilson & Devinney 1971; Wilson 1979). Due to the lack of spectroscopic mass ratio of the system, the q-search method was applied in Mode 2, 4 and 5 in order to find the most probable value of the (photometric) mass ratio (q).

The least squares method with statistical weights has been used for the analysis of the O-C diagram. The current O-C diagram of X Tri includes 572 times of minima taken from the literature. The following ephemeris: $Min.I = HJD\ 2422722.285 + 0.9715341^d \times E$ (Kreiner et al. 2001) was used as the initial one for the O-C analysis of the compiled times of minima.

2 Discussion and Conclusions

The results of the LCs solution (see figure 1 and table 1) show that X Tri is a semi-detached system with the secondary star filling its Roche Lobe. The periodic variations of the orbital period of the system could be explained by adopting the existence of three additional components, which were found to

have minimal masses 0.18, 0.24 and 0.22, respectively (see figure 1 and table 2). An extra light contribution to the luminosity of the EB was taken into account in the LCs solution but it was found to be less than 1%. Such a small extra luminosity could be explained by the small values of the minimal masses of the possible additional components found. The steady decrease rate of its period is probably due to angular momentum loss, since the direction of the flow (from the more massive to the less massive component), revealed from the O-C diagram analysis, comes in disagreement with the one derived from the LCs analysis.

Table 1. The parameters of X Tri derived from the LCs solutions

Parameter	**value**	**Parameter**	**value**			
q (m_2/m_1)	0.599 (2)		B	V	R	I
i (deg)	87.9 (1)	x_1***	0.551	0.478	0.402	0.322
T_1**(K), T_2 (K)	8600, 5188 (4)	x_2***	0.835	0.692	0.597	0.503
A_1*, A_2*	1, 0.5	L_1/L_T	0.893 (2)	0.839 (2)	0.795 (2)	0.739 (1)
g_1*, g_2*	1, 0.32	L_2/L_T	0.107 (1)	0.160 (2)	0.201 (2)	0.246 (3)
Ω_1, Ω_2	4.27 (1), 3.06	L_3/L_T	0.000 (1)	0.000 (1)	0.004 (1)	0.015 (2)
χ^2	1.278					

assumed,* * Giuricin et al. (1983),* **** Van Hamme (1993),* $L_T = L_1 + L_2 + L_3$

Table 2. The results of the O-C diagram analysis for X Tri

Parameters of the EB	**value**	**Parameters of the LITEs**	**value**		
$M_1^* + M_2$ ($M_\odot$)	2.1 + 1.26		$3^{rd}body$	$4^{th}body$	$5^{th}body$
$Min.I$ (HJD)	2442502.731 (2)	P (yrs)	36.9 (5)	22.4 (3)	16.8 (4)
P (days)	0.9715318 (2)	T_0 (HJD), ω (deg)	2452916 (373), 220 (98)	2455069 (335), 34 (13)	–, –
c_2 ($\times 10^{-10}$)	-2.0308 (2)	A (days), e	0.0052 (3), 0.2 (2)	0.0040 (4), 0.5 (1)	0.003 (2), 0.0
$\dot{P}$ ($\times 10^{-10}$)	-1.5269 (2)	M_{min} ($M_\odot$)	0.18 (1)	0.24 (1)	0.22 (1)

**assumed*

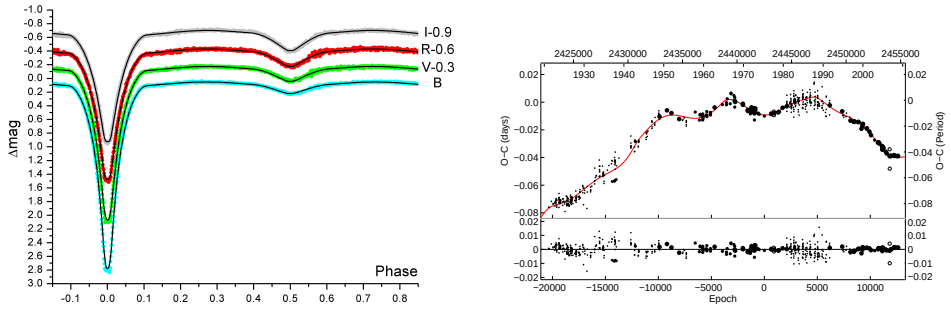

Figure 1. Left panel: The synthetic LCs (black solid lines) along with the observed ones (colored points). Right panel: The multiperiodic fitting (red solid line) on the O-C points (black points) (upper part) and the O-C residuals (lower part).

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